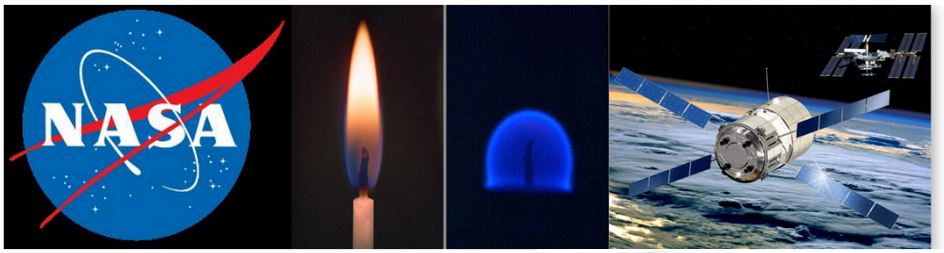
Unmanned Vehicle Material Flammability Test



David L. Urban and Gary A Ruff: NASA Glenn Research Center, Cleveland, OH, USA
A. Carlos Fernandez-Pello: UC Berkeley, Berkeley, CA, USA
James S. T'ien: Case Western Reserve University, Cleveland, OH, USA
Jose L. Torero University of Queensland, AU
Adam Cowlard: University of Edinburgh, Edinburgh, UK
Sebastien Rouvreau: Belisama R&D, Toulouse, France

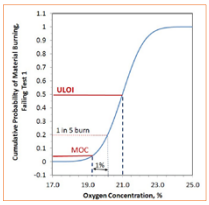
Olivier Minster and Balazs Toth: ESA ESTEC, Noordwijk, Netherlands
Guillaume Legros: Université Pierre et Marie Curie, Paris, France
Christian Eigenbrod: University of Bremen (ZARM), Bremen, Germany
Nickolay Smirnov: Moscow Lomonosov State University, Moscow, Russia
Osamu Fujita: Hokkaido University, Sapporo, Japan
Grunde Jomaas: Technical University of Denmark, Kgs. Lyngby, Denmark

International Topical Team

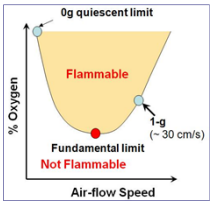
The experiment is an international collaboration between numerous space agencies. The collaboration is managed by an International Topical Team including participation by NASA and ESA, plus a **group of international scientists (pictures below)**, that aims to revolutionize spacecraft fire safety designs for next-generation space vehicles and habitats. It will feature a validation experiment on an unmanned but pressurized vehicle such as the Orbital Sciences Corp. Cygnus vehicle after it has completed its supply mission to the International Space Station.

Problem Identification

Full scale fire testing complemented by computer modeling has substantially improved our understanding of the risk, prevention and suppression of fire in terrestrial systems (cars, ships, planes, buildings, mines, and tunnels). In comparison, no such testing has been carried out for manned spacecraft due to the complexity, cost and risk associated with operating a **material flammability experiment of a relevant size and duration in microgravity**. Therefore, there is currently a gap in knowledge of fire behavior in spacecraft.



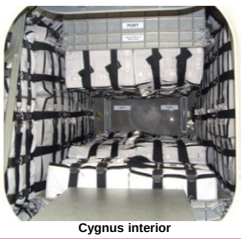
NASA Test1 challenges



Flammability limits differ

Vehicle Configuration

Cygnus approaching the ISS

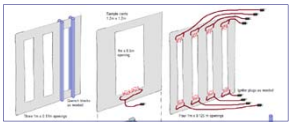


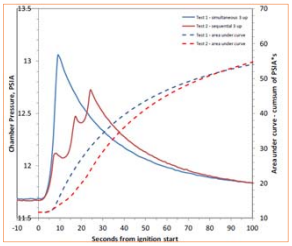
Cygnus interior

Cygnus in Shroud

Overpressure Testing and Modeling

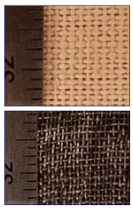
The experiment will need to meet rigorous safety requirements to ensure the carrier vehicle does not sustain damage



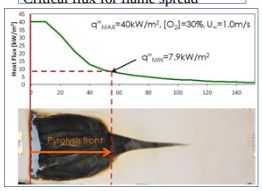


Ground Experiments

SIBAL before and after test



Critical flux for flame spread



Soot measurements in flame (backlighting technique)

Experiment Configuration

Experiment Installed in Cygnus
Thrust vector aligned with x-axis
Foam on both sides and bottom of Saffire

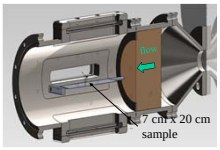
Cutaway view of the flow duct and avionics enclosure

Parabolic Flight Experiments

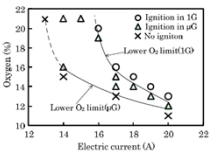
A new rig for parabolic flight is being built. Team members will conduct short duration validation experiments before every Cygnus flight experiment

Novespace's plane

New combustion chamber

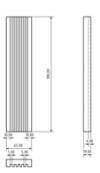


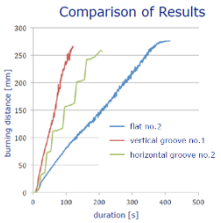
Drop Tower Experiments



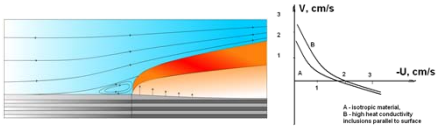
Sample Selection

Structured Samples





Flame spread over thin combustible layer with high heat conductivity inclusions



Streamlines

Flame velocity versus flow velocity

The Road Ahead

The large-scale material flammability demonstration will facilitate the understanding of the long-term consequences of a potential spacecraft fire and provide data not only for the verification of detailed numerical models of such an event, but also for the development of predictive models that can assist and optimise fire prevention, response and mitigation.

The first step is to provide an predictive tools that will integrate fire safety into design and management of space vehicles. Such tools will integrate a wide range of design issues including, but not limited to, material selection, emergency response, crew training, post-fire clean-up, fire detection, fire suppression, environmental control and life support (ECLS) system design, and even atmosphere selection to provide a globally optimised solution.

Contact David Urban (david.urban@nasa.gov) and / or Grunde Jomaas (grujo@byg.dtu.dk) for more information or to express interest in participation.